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Agricultural Research

Remote Sensing Technology— A Window on Tomorrow

This past summer, Anson Bertrand, director of science and education, addressed the International Symposium on Machine Processing of Remotely Sensed Data at Purdue University, Ind. The following is based on his remarks:

Remote sensing has become an important part of high-technology agriculture. It gives us vital information for today and a picture window on tomorrow.

The tomorrow for the moment may be only the time between spring planting and fall harvest, but remote sensing allows us to look ahead with a wholeness of perspective never before conceived. This perspective comes "alive" as we see faults and domes, color changes, and moisture patterns that might be imperceptible at ground level.

Our scientists are already using remote sensing to predict range forage availability. The same technology might be adapted to forecasting the availability of agricultural biomass for fuel alcohol fermentation plants, and to predicting crop yields and effects of adverse weather.

Survival on earth is to a large measure dependent on how we use our available resources. We are influenced by fluctuating weather patterns, drought, increasing desertification, oil supply problems, the world food situation, increasing population, the finiteness of our land and water resources, overuse and erosion of our lands, and others. We need more information on these factors and their interrelationships. Remote sensing has the potential to supply some of this essential information.

Research is critically needed in a number of areas. Take nonpoint source pollution assessment and control as examples. The task is staggering when we consider the sheer amount of land involved and all the variables of soils, crops, cultural practices, and weather.

SEA scientists have developed a nonpoint source pollution model for agricultural fields called CREAMS (Chemical Runoff, Erosion And Management Systems). We must develop other models such as CREAMS to detect and predict the effect of various management practices on soil erosion, on transport of agricultural chemicals, and on water quality. By using these models, we can begin to make better management decisions on research to improve the quality of the environment.

Cooperative efforts are essential if we are to get this job done—cooperative efforts of the type represented in the AgRISTARS (Agricultural Resources Inventory Survery Through Aerospace Remote Sensing) program. AgRISTARS is a joint project involving USDA, the Department of Commerce (USDC), the Department of Interior (USDI), the National Aeronautics and Space Administration (NASA), and the Agency for International Development (AID).

Another area of importance is agricultural productivity. We know that the rate of increase in productivity per unit of land for many crops is slowing down and tending to level off. We know that we are losing more and more of our prime farm land to other uses. We know that the number of scientists at work on food and agricultural problems today is only slightly more than it was a decade ago. Remotely sensed and automatically processed data will help us better cope with these problems.

Other areas of concern include: the training of young scientists, the providing of information to other countries, and the cooperation of other countries in managing technologies that have global impact.

Still, we must persist in the development of new technology. From remote sensing research that has been done, we know that:

- Remotely sensed data can be used in conjunction with ground data to improve yield estimates. The former ESCS (now ESS) last year used information collected by the Landsat satellite to improve the final USDA yield estimates for corn and soybeans in the State of Iowa.
- Remotely sensed data can improve the efficiency of soil surveys. Working with scientists at Purdue University, SCS has developed techniques to use satellite data in conjunction with ground data to make soil surveys over wide areas more cohesive than ever before.
- Satellite data can be used to determine the effects of solar radiation on the earth's surface. SEA and NOAA scientists have developed techniques using satellites to produce daily radiation input maps essential to understanding crop yield variation and changes in the biosphere. (Feature article in this issue of *Agricultural Research*.)

The potential exists for using satellite data to make wheat commodity forecasts as demonstrated in the LACIE (Large Area Crop Inventory Experiment) program.

Agricultural research is turning toward methods of raising productivity that take maximum advantage of existing biological systems through new technologies and information. By extending the application of these technologies and information through remote sensing, we are developing a new awareness of the interactions of all components of the biosphere.

We will continue to need research on erosion, improved tillage, multiple cropping, better irrigation, nitrogen fixation, photochemistry, and numerous other areas. We will develop new and innovative production systems. We do know that efficiencies can indeed be made, that the agricultural system is going to change in a new energy economy, and that our data requirements both locally and globally will be numerous. Remotely sensed processed data will be essential.

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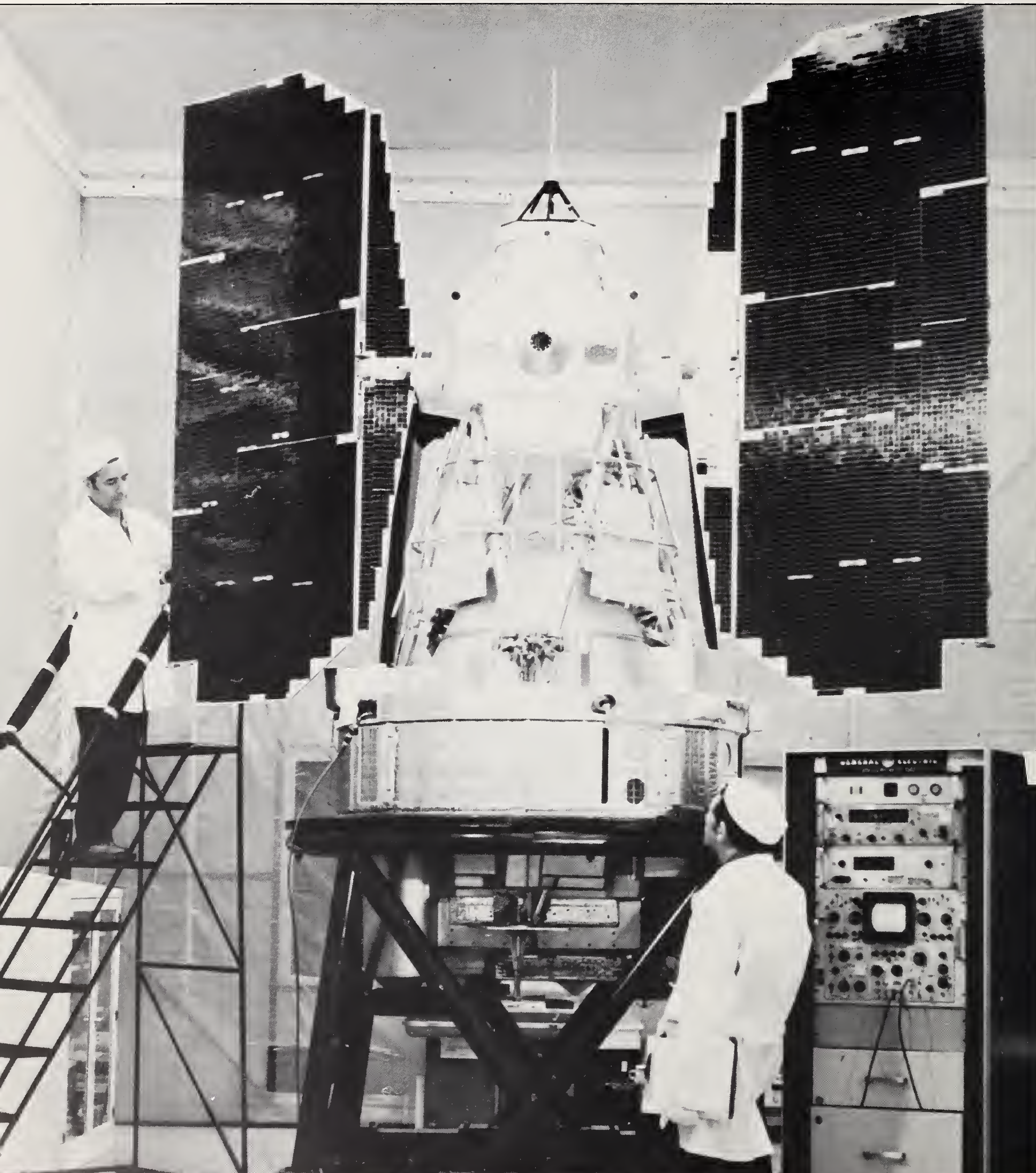
Cover: Remote sensing technology, long used by agricultural researchers and statisticians to paint a big picture on crop conditions throughout the country, has gained new heights and a global brush through imagery and data transmitted by satellites. Article begins on page 4 (1080X1245-17).



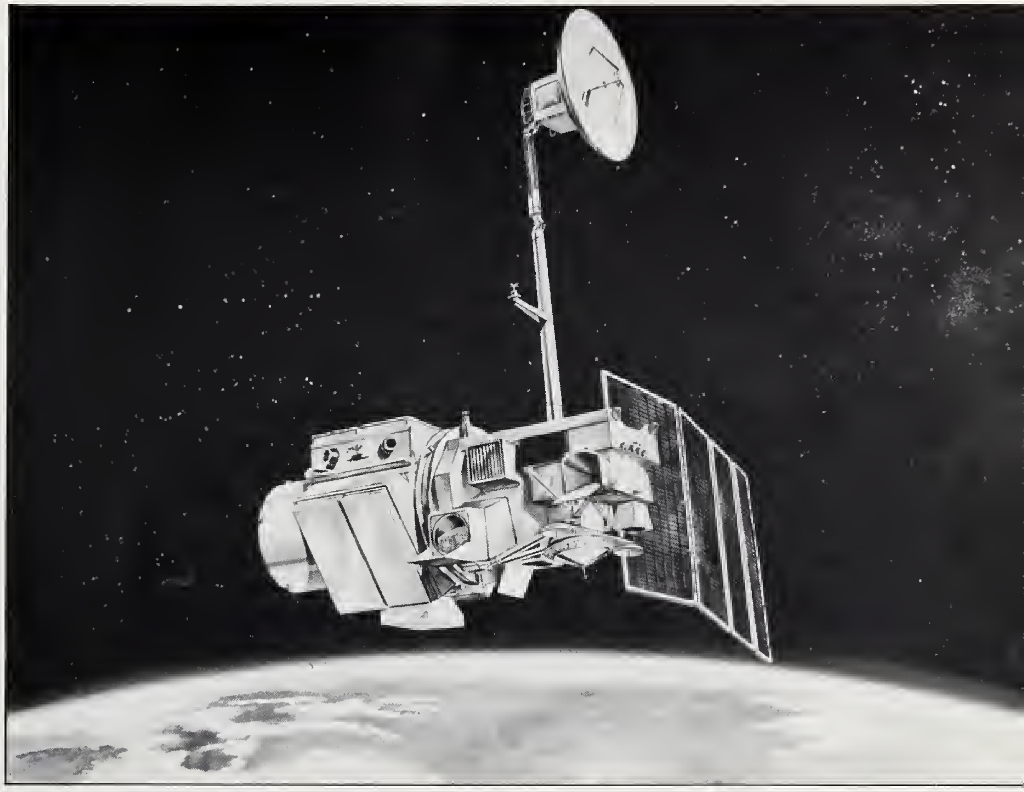
Landsat and AgRISTARS

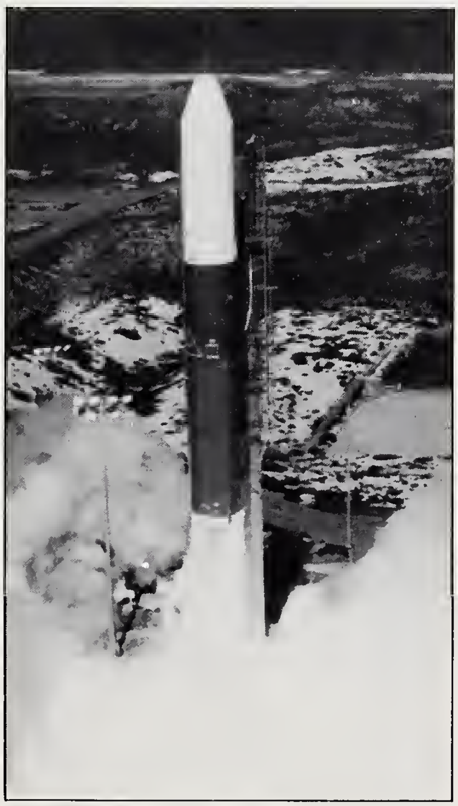
Sensing something from afar—that's remote sensing. Conceivably, every photographer shooting through a telephoto lens is a remote sensor of sorts. In a more technical sense, remote sensing refers to the aerial or satellite detection of specific wavelengths in the electromagnetic spectrum as reflected or emitted by crops, forests, mineral deposits, oil, soil moisture, and other earthbound resources.

USDA has long used remote sensing technology to provide information for many of its research, planning, and regulatory activities. In the mid-1960's, a remote sensing research unit was established in Weslaco, Tex., by the former Agricultural Research Service (ARS) to help determine better ways to use remote sensing technology in agriculture. This unit continues to be a pioneer in understanding the spectral (light reflectance) properties of various crops.

In 1974, USDA joined with the National Aeronautical and Space Administration (NASA) and the National Oceanic and Atmospheric Administration (NOAA) in a cooperative effort to determine the value of remotely sensed information from satellites. Called LACIE (Large Area Crop Inventory Experiment), this project demonstrated that satellite data—coupled with ground-based information—could be used to estimate wheat yields. The LACIE project used data from NASA's satellites.

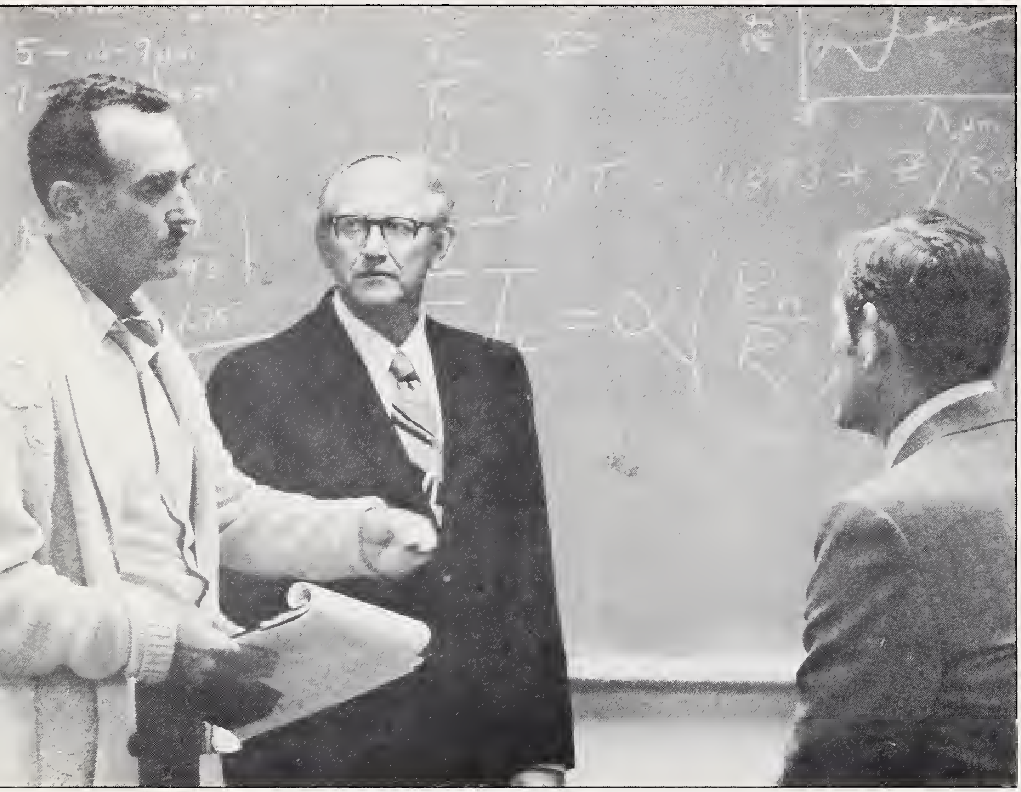
NASA launched the first satellite dedicated to land resources observation in 1972. A second was launched in





Opposite page: Landsat III, the third in a series of Earth Resources Observation Satellites receives some last minute adjustments before being launched into a 565-mile high orbit on March 5, 1978 (left). This was the first satellite to "photograph" natural resources such as water, agricultural fields, and mineral deposits in total darkness. Scheduled for launch in fall 1981, Landsat IV (artist's rendering, above) will transmit a more detailed picture of the earth through improved remote sensing technology. *Photographs and illustration courtesy of NASA.*

Predicting Crop Yields Via Satellite



1975 and a third in 1978. These satellites were originally known as Earth Resources Technology Satellites (ERTS), but were renamed Landsat in 1975.

Landsat measures four bands of electromagnetic radiation reflected from the earth's surface. These measurements are transmitted much like a television signal, line by line, as a series of numerical values, to ground receivers 570 miles below. Computers then convert this digital information into composite images which resemble photographs.

Each image covers about 13,000 square miles and contains about 7.5 million separate data points called "pixels." Each pixel represents about 1.1 acres of land surface.

Data from Landsat are being used by many nations for studies in such diverse areas as: mineral and oil exploration, land-use analysis, crop and forest inventory, geological mapping, urban development analysis, map and navigation chart development and updating, and water resources analysis.

USDA, NASA, NOAA, U.S. Department of Interior, and the Agency for International Development have now joined in another cooperative effort to further explore the application of remotely sensed data to meeting agricultural needs. Known as AgRISTARS (Agricultural Resource Inventory Survey Through Aerospace Remote Sensing), this research project currently encompasses eight areas: early warning, foreign commodity production forecasting, yield model development, soil moisture, supporting research, domestic crops and land cover, renewable resources inventory, and conservation and pollution.

Within USDA, the following agencies participate in AgRISTARS: SEA, Foreign Agricultural Service, Forest Service, Economics and Statistics Service, Soil Conservation Service, and the World Food and Agriculture Outlook Situation Board.

SEA scientists are now developing mathematical models to estimate crop yields. These models, linked with data from the Landsat satellite on crop acreage, may be useful in making global crop yield predictions.

"The mathematical models describe plant growth and yield and are designed to handle the vast amounts of information required for accurate crop yield estimates," says Jerry C. Ritchie, SEA national research program leader for Aerospace Technology.

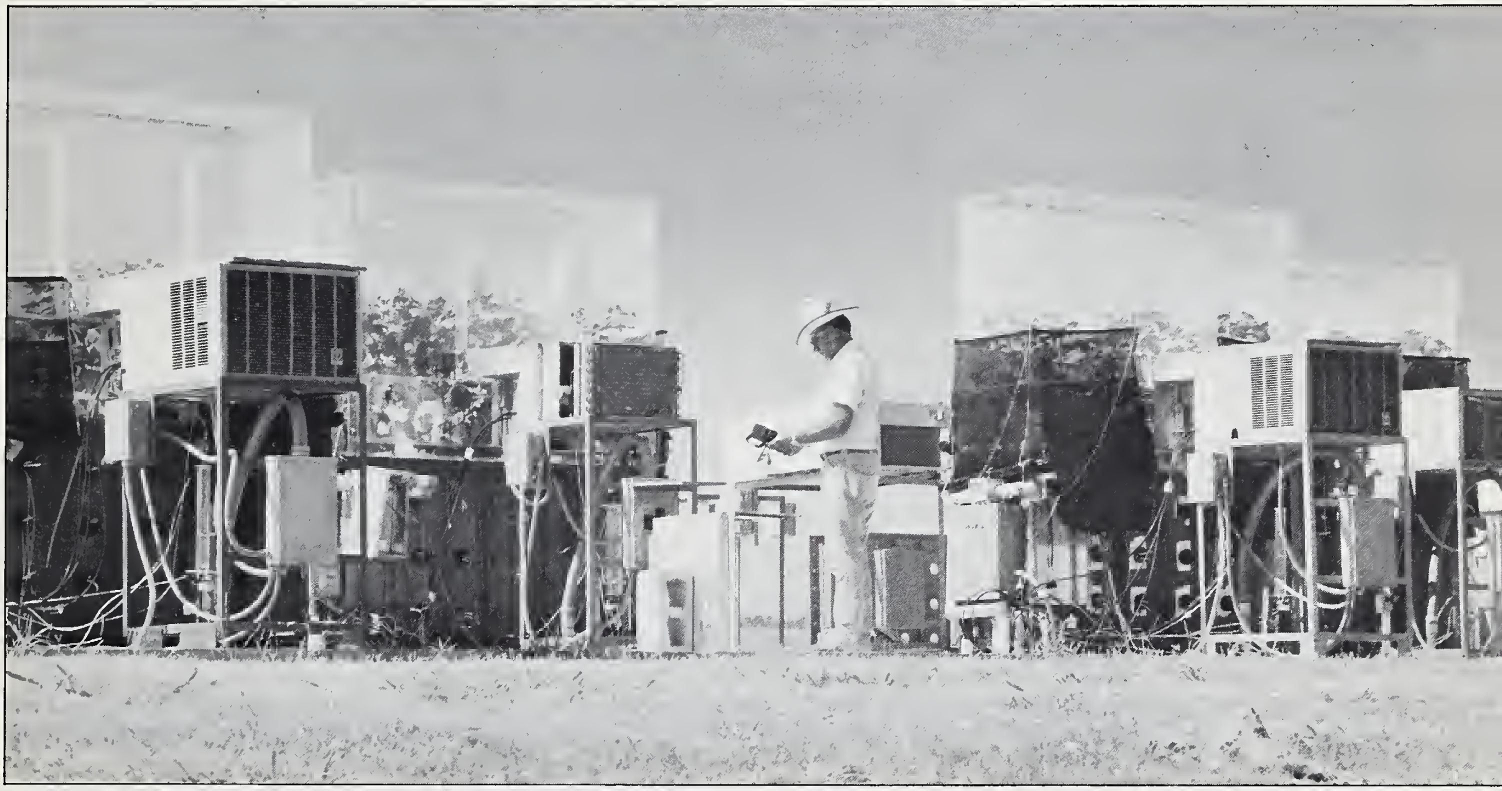
The yield of any crop depends on many factors—such as soil moisture, fertility, climatic conditions, management practices, weed control, plant genetic makeup, disease, and insects. And each of these factors has many subfactors. For example, soil water depends on: amount of rainfall, snow accumulation and how it is distributed across fields, salinity, and evaporation from soil and plant surfaces.

Not considering any one factor or even one subfactor, or not having accurate or sufficient data, may cause an incorrect estimate of crop yield.

Crop yields are variable. For example, wheat, the most internationally traded food grain, is grown mainly in areas where variations of just a few inches of precipitation can mean a bumper crop or a disaster. Satellite monitoring of crops worldwide during the entire growing season could help agricultural agencies better estimate global crop production.

Accurate global crop yield information is important to U.S. foreign trade of agricultural products. According to USDA's Foreign Agricultural Service (FAS), which is responsible for global crop assessments, more than 1,000 agricultural products comprised 20 percent of this country's total export trade in fiscal year 1980.

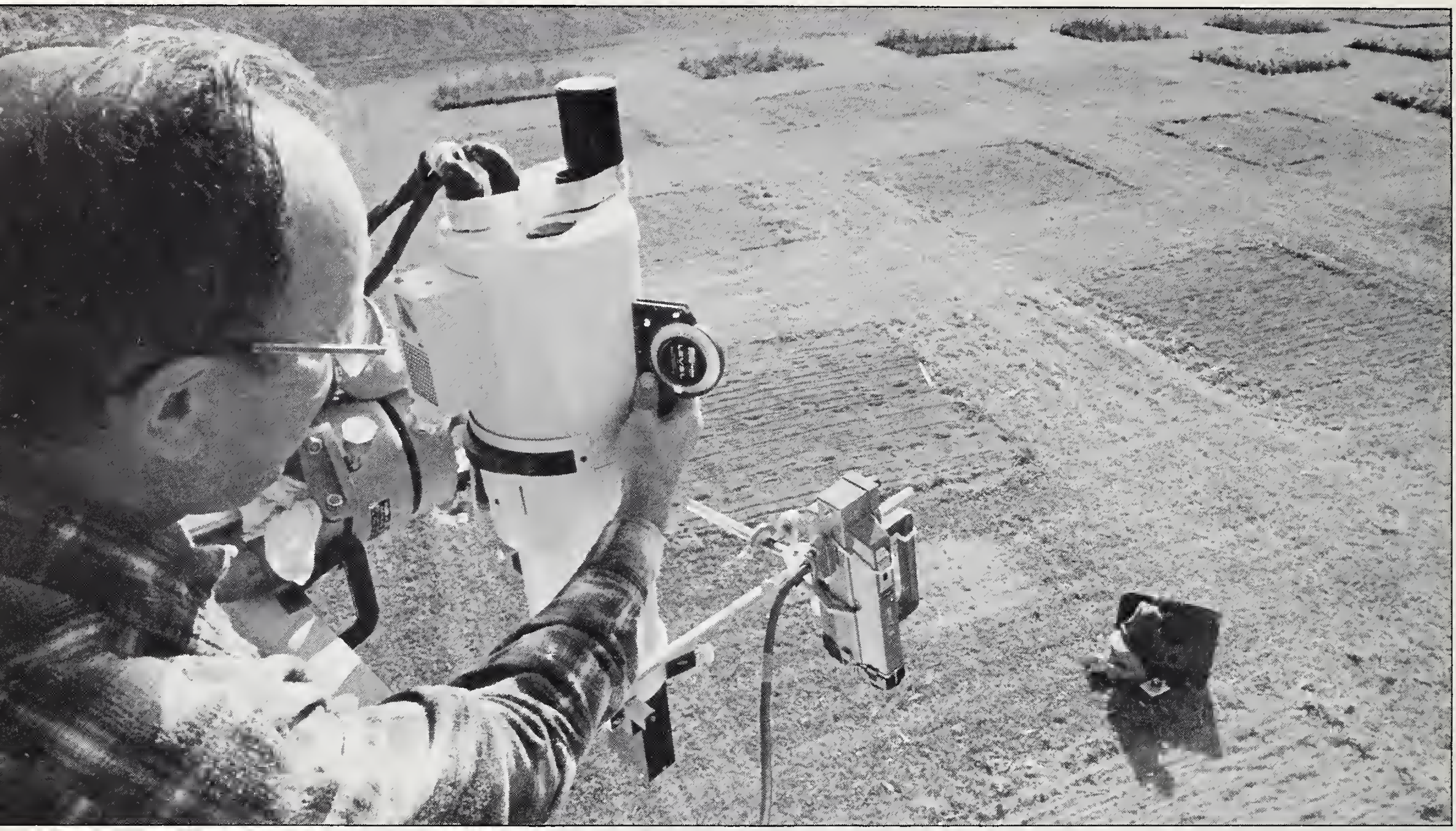
Because some foreign countries do not collect data on their expected harvest or do not release this information until after harvest, world supply of agricultural products has been difficult to predict. Research is underway to apply crop yield models developed by SEA with crop acreage data obtained



Above: Measuring the height of cotton plants inside one if the SPAR units is Dr. Avishalom Marani, a visiting plant physiologist from Israel. Other data from these SPAR units will include the rate at which new leaves, fruits, and stems appear, and the rate at which leaf area expand (0880X1045-28).

Opposite page: Blackboard harvest—At a recent conference in Washington, D.C., crop scientists from across the Nation met to discuss their latest research in remote sensing—including the mathematical modeling of crop physiological processes. In crop modeling, data transmitted by satellite are plugged directly into mathematical formulas that predict crop performance. Reviewing the algebra of tomorrow's food supply are (from left to right) SEA wheat physiologists Donal Baker, Dale Heerman, and Craig Weigand. Some refinements in the models are still needed, but eventually the mathematics of plant physiology may prove more reliable than the statistical models currently used for crop forecasting (1078W1278-2).

Top: Far from being a mere exercise in theoretical mathematics, crop modeling constructions have a firm foundation in the soils of SPAR. These SPAR (Soil-Plant-Atmosphere Research) units enable scientists to monitor the growth of various crops under precisely controlled environmental conditions that will not "corrupt" the physiological data. At this SPAR installation in Mississippi State, scientists are growing cotton, soybeans, and wheat in studies that will lead to related crop simulation models. In addition to remote sensing applications, the models will be used in crop breeding programs and continued research in plant physiology (0880X1045-33).



Above: At Beltsville, test plots established by SEA researchers enable NASA engineers to refine the instrumentation used in remote sensing. Here, NASA technical specialist Frank Wood adjusts a multiband radiometer that scans the spectrum from visible blue thru infrared wavelengths. NASA is responsible for remote sensing hardware; SEA provides the agronomic expertise that makes the remotely sensed data relevant to actual crop conditions (1178X1494-30).

Right: Satellite images are also applied to computer-generated maps that outline crop "histories" and soil and climate conditions for the same area. These combined displays enable USDA statistician Lyle Lautenschlager to develop new mathematical procedures utilizing Landsat imagery for predicting crop yields (1080X1244-20).

Opposite page: Data from Landsat can be analyzed visually, as well as mathematically. At the NASA Space Center in Houston, SEA agronomist T. W. Taylor takes a close look at pictures transmitted from Landsat II and III. These photographs cover four wavelength bands in the blue thru infrared end of the electromagnetic spectrum (1080X1243-9).

from Landsat. This will aid FAS in making more timely and accurate estimates of global crop production.

One such research project is AgRISTARS (Agricultural Resource Inventory Survey Through Aerospace Remote Sensing). AgRISTARS couples Landsat data, weather satellite data, and crop yield model development in a coordinated effort to relate aerospace technology to agricultural needs (See accompanying article).

"Use of satellites equipped with remote sensing devices is perhaps the fastest, most efficient method of collecting global crop acreage information," says Ritchie.

"Predicting yield with satellites 500 or more miles above fields is as complex as landing men on the moon. Remote sensing of crop yields involves biological and physical processes which are constantly changing in response to the environment. These processes are often difficult to express mathematically—which is why the models being developed by SEA researchers will be beneficial."

Because of wheat's important role in world trade, a major AgRISTARS project for SEA is predicting its yield. The SEA Wheat Yield Group is conducting research at many locations across the country. Locations involved and examples of research are listed below:

- *Fort Collins, Colo.*—Developing and testing models of wheat growth and yield, and analyzing plants and climate data from field sites in the U.S. wheat-producing areas.
- *Akron, Ohio.*—Collecting plant and climate data from large wheat fields at seven sites, representing various climates of the Central Great Plains. Use of the data includes testing of various SEA wheat growth models.
- *Bushland, Tex.*—Collecting plant and climate data from field sites in the Southern Great Plains for testing SEA wheat models, and determining the effects of soil water on plant growth.
- *Houston, Tex.*—Extracting Landsat data for SEA test fields and determining application of satellite data for estimating crop conditions.
- *Mandan, N. Dak.*—Studying U.S. and Soviet spring wheat varieties to determine relationship of growth and dry matter accumulation to fertilizer and soil water levels and yield in the Northern Great Plains.
- *Pendleton, Ore.*—Collecting information on stubble management and tillage and how it relates to water conservation and wheat production in the Pacific Northwest. The data will also be used for testing SEA wheat models. Developing models of wheat tiller formation and growth.
- *Phoenix, Ariz.*—Evaluating spectral reflection of crops and assessment of thermal data for estimating water deficits, plant stress and plant conditions as related to yield.
- *Sidney, Mont.*—Measuring climatic factors, soil temperatures, snow cover, and relating these measurements to various stages of wheat growth. Comparing U.S. and Soviet winter wheat varieties.
- *State College, Miss.*—Developing

and testing physiological-process oriented plant models for wheat, which include influence of insects, weeds, and diseases on yield.

- *Temple, Tex.*—Developing and testing ecological growth and yield models for wheat.
- *Weslaco, Tex.*—Collecting data for wheat varieties grown under semitropical conditions and developing techniques for utilization of spectral data from remote sensors in crop yield models.

Dr. Jerry C. Ritchie is located at the Beltsville Agricultural Research Center, Building 005, Room 239, BARC-West, Beltsville, MD 20705.—(By Dennis Senft, SEA, Oakland, Calif.)

Above: Inside an instrumentation trailer, NASA technical specialist John Fuchs checks data from a microwave sensor being developed to assess soil moisture conditions. Use of natural microwave emittance as a basis for the remote measurement of soil moisture is still uncertain because cloud covers and plant canopies can significantly affect the readings. SEA and NASA scientists must continue to refine microwave detection and other remote sensing techniques (1178X1494-13).

Left: Wheat yield levels are closely related to the supply of soil water during the growing season. Here, a neutron probe is used to measure this supply to a depth of 6 feet. When Americium-Beryllium neutrons emitted from the probe strike hydrogen atoms in the soil, a percentage of the neutrons will bounce back to the probe's detector tube—thus providing a count, or index, of soil water content. Research technician James Harms makes this count on a weekly basis (1080X1242-12A).

Above: Satellites can photograph fields of wheat and measure their electromagnetic radiation, but how does this remotely sensed information relate to the actual condition of the crop? To get a precise answer, soil scientist Armand Bauer counts the number of heads per square meter. This is a determining factor in wheat yield, as well as kernels per head and kernel weight. (1080X1239-24).

Top left: Establishing "ground truth" in Mandan, N.D.—As a satellite equipped for remote sensing silently streaks 500 miles directly overhead, research technician Roland Vredenburg measures specific wavelengths of radiant energy from the wheat right at his feet. Simultaneously, the satellite is also measuring wavelengths from the same field. When readings from the handheld radiometer are correlated with crop conditions and performance, equivalent data from the satellite radiometer can be used to help determine crop conditions on a regional, national, or even global scale (1080X1238-28).

Left: If a radiometer measures specific wavelengths of electromagnetic radiation, what does an anemometer measure? Wind speed, naturally. And the wind, like various other elements of the weather, can have a significant affect on crop performance. Here, research technician Roland Vredenburg connects an anemometer and net radiometer to a sensor that feeds weather data to nearby electronic recording devices (1080X1240-17).

Screwworm Eradication Program: An Overview

The screwworm eradication program has eliminated populations of this livestock pest from the southeastern and southwestern United States and drastically reduced screwworm populations in areas of northern Mexico.

As a direct result of the program, the number of reported screwworm cases in the United States has been cut from 95,650 in 1972 to 90 in 1979. So far, only two cases have been reported in the United States this year.

Begun in the United States in 1958, the program has been a cooperative effort of USDA, various states, and industry. Within USDA, the Animal and Plant Health Inspection Service (APHIS) implements and administers the program through its Veterinary Services (VS) branch. SEA research is conducted at facilities in Mission, Tex., Fargo, North Dak., and Tuxtla Gutierrez, Mexico. (See accompanying articles.)

In Mexico, the joint Mexico-U.S. Commission on Screwworm Eradication was authorized in 1972 to establish a joint program in the Republic of Mexico to eradicate screwworms north and west of the Isthmus of Tehuantepec and to establish a barrier at the Isthmus.

The screwworm is an economically harmful pest of livestock. Uncontrolled, it could cost producers in Texas alone more than $375 million per year. The larval stage of the screwworm fly infests wounds and destroys living tissue in any warm-blooded animal. Multiple infestations can kill a grown steer in 10 days.

Because the female screwworm fly usually mates only once, the program can successfully employ sterile fly release techniques. Hundreds of millions of flies are reared each week in two fly rearing factories—one at the SEA Screwworm Research Laboratory in Mission, Tex., the other in Tuxtla Gutierrez, Mexico.

While in the pupal stage, flies are sterilized with gamma rays. After emerging, they are released by airplane over infested areas. Sterile males mate with native females, competing with fertile males in their natural environment. Eggs from these matings do not hatch, thereby drastically reducing the number of wild flies.

In areas of high infestation, the program implements the Screwworm Adult Suppression System (SWASS) in addition to sterilization. Airplanes distribute pellets containing an attractant, bait, and pesticide. Adult flies then feed on the pellets and die.

The program also encourages frequent inspection and treatment of livestock by producers.

From egg to adult fly, the screwworm's life cycle takes about 12 days. The insect's mouth at the "pointed end" and its dark-lined digestive tract near the "broad tail" are highlighted in this enlarged photo of the larvae (PN-6812).

Cottage Cheese Cut from Screwworm Diet

By demonstrating that cottage cheese could be cut from the menu, a SEA chemist has found a way to cut $750,000 annually from the cost of an artificial diet used in the screwworm eradication program.

Working at the SEA Screwworm Research Laboratory, Mission, Tex., SEA chemist Harold E. Brown found that cottage cheese can be eliminated totally from the screwworms' diet, and the amount of dried blood—a much cheaper ingredient—can be increased. Cottage cheese was the single most expensive ingredient in the diet, costing nearly $1 million per year based on present production.

Brown also found that any growth delay of screwworm larvae can be offset by using surplus cheap, dried, nonfat milk that is unfit for human consumption.

While the screwworm eradication program would be possible without the artificial diet, it would be vastly more expensive. Cost and availability preclude the use of meat—the screwworm's natural food—in larval diets.

Approximately 2 million pounds of the artificial diet is currently being used in Texas and Mexico, where screwworm larval rearing plants are producing about 350 million sterile flies per week.

As a buffer against infestation of the United States, SEA scientists are working with the Animal and Plant Health Inspection Service (APHIS) in cooperation with Mexico to find better ways to suppress and eradicate the pest in Mexico.

Dr. Harold E. Brown is located at the SEA Food Crop Utilization Research Laboratory, P.O. Box 267, Weslaco, TX 78596.—(By Bennett Carriere, SEA, New Orleans, La.)

New Sterile Screwworm Strain Saves Livestock

Above: Factory workers transfer larvae from the starting trays to production trays and regularly examine their growth. Mature larvae crawl to the edge of the production tray and drop into a running water gutter that carries them to a collection point. Larvae are then placed in sawdust, a soil substitute, to pupate and are sterilized just prior to emerging as adult flies (0976X1125-8).

Right: Starting trays each contain 200,000 screwworm larvae about to begin their life cycle after removal from petri dishes. Workers in this rearing facility in Tuxtla Gutierrez, Mexico, prepare the screwworm diet from dried animal blood (taken from slaughter houses), water, dried eggs, formalin, and linters cotton (0479X476-26).

By developing a more effective strain of screwworm flies, SEA entomologist James R. Coppedge has helped solve a chronic screwworm problem in Aldama, Mexico, that threatened livestock in Texas—200 miles to the north.

Coppedge used wind-oriented traps baited with a chemical to attract adult screwworm flies and pens of "sentinel," or control, sheep to monitor fertile eggs laid by the fly. After extensive field testing, he found that the strain of sterile male flies being dropped from airplanes was not competing successfully for native females in the area. Although sterile screwworm flies were abundant in the area, eggs collected from the sentinel sheep were essentially all fertile when the test began.

Coppedge conducted a test in which he substituted a new strain of the fly for the ineffectual one and the effect was quick and dramatic. Within 2 weeks of the first drop of the new strain, (reared and dropped directly from the APHIS Mission, Tex., facility), 60 percent of the collected egg masses were sterile. By September 1979, the screwworm population had been so suppressed that scientists were unable to trap native screwworms or find egg masses on the sheep.

Cooperation by area cattle producers contributed to the success of the suppression program. These producers identified "hot spots" of screwworm infestation for heavy drops of sterile flies and treated wounds on their livestock to avoid pest infestation.

"Our test," says Coppedge, "shows that outstanding results can be obtained in the fight against the screwworm by using an integrated approach that involves research, action by our sister agency, APHIS, and good animal care by producers."

Dr. James R. Coppedge is located at the SEA Screwworm Research Unit, P.O. Box 986, Mission, TX 78572.—(By Bennett Carriere, SEA New Orleans, La.)

Proteus Bacteria Linked to Screwworm Life Cycle

Bacteria of the genus *Proteus* may have a role in growth and reproduction of the screwworm fly. In its larval form, the fly lives as a parasite in wounds of cattle and other warm-blooded animals.

SEA scientists have isolated five species of *Proteus* bacteria in screwworm larvae and pupae as well as in various larval-feeding media, including fluids from screwworm-infested animal wounds.

"If these bacteria and screwworms are not co-existing for some specific reason, the isolation of the same species over and over again is hard to explain," says SEA geneticist George Gassner, at the Metabolism and Radiation Research Laboratory, Fargo, N. Dak.

Combinations of *Proteus mirabilis, P. vulgaris, P. morganii, P. rettgeri,* and *P. inconstans* were detected in more than two dozen isolations from laboratory and field samples obtained in Texas, North Dakota, and Mexico. Not all the *Proteus* species were found in a given sample and different ones predominated in different samples, sometimes in association with other kinds of bacteria. However, Gassner says at least one *Proteus* was consistently present. In three cases, the only bacterium was a single *Proteus* species.

Based on their observations, Gassner, North Dakota State University bacteriologist Mary C. Bromel, and SEA entomologist Leslie Hammack suggest the following areas for potential exploration:

- *Proteus* bacteria may produce an attractant that helps female flies locate animal wounds, the only place they lay their eggs.
- Genetic variation in screwworm populations may result from associated bacterial populations.
- *Proteus* bacteria may be furnishing amino acids to developing screwworm larvae, since these bacteria secrete enzymes that stimulate protein synthesis.
- Preliminary electron microscopic examination suggests that *Proteus* bacteria may weaken the puparia, helping adult screwworm flies emerge.

In laboratory olfactor tests, Hammack and Bromel found that bacteria cultures of *P. rettgeri* attracted up to 80 percent of egg-laying females, depending on the dilution of the inoculated broth. And *P. rettgeri* has been isolated from wounds containing larva.

Identifying the wound attractant would help the joint effort of USDA's Animal and Plant Health Inspection Service (APHIS) and the Mexican government to suppress and control the pest.

The researchers have not yet explored the other potentially fertile areas of investigation, but they hypothesize the existence of a specific and functionally significant screwworm-*Proteus* association.

"So far, we have a highly interesting hypothesis," says Gassner, "one that could open a new area of research if it is supported by future research results. Perhaps specific bacteria are similarly associated with other pest insects."

Dr. George Gassner is located at the SEA Metabolism and Radiation Research Laboratory, P.O. Box 5674, State University Station, Fargo, ND. 58105.
—(By Walter Martin, SEA, Peoria, Ill.)

Top: Sterilized pupae, usually packaged 1,500 to 2,000 to a box, are loaded aboard a plane for release over infested areas. The infertile adult screwworm fly emerges from its pupal shell while still in the box (0872A1217-30).

Above: Screwworm infestation is painfully evident on this Brahma steer. Adult flies lay eggs on any wound. The eggs hatch within 12 hours, and larvae begin feeding on the wound—making it more enticing as a nest for other files. These wounds were treated with Coumaphos insecticide—otherwise the steer would have died in 10 days (BN-43414).

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Agrisearch Notes

Sugarbeet Cyst Nematodes. A better method for determining field populations of sugarbeet cyst nematodes has been developed by SEA plant pathologist Gerald D. Griffin, Logan, Utah.

Griffin's method should provide the accurate population counts that sugarbeet growers need in deciding whether or not to treat their fields. "The U.S. sugarbeet industry is on shaky economic grounds and field production costs must be kept as low as possible," says Griffin.

Nematode infestations—if severe enough—have to be treated, but current treatments are too expensive to be used unnecessarily. Accurate population counts are needed to predict the economic damage resulting from untreated beet fields.

Traditionally, sugarbeet cyst nematode population counts have been based on the number of viable cysts in field soil samples. A cyst is a dead female nematode which houses eggs that can hatch and infect the sugarbeet seedling.

Griffin has found that the number of cysts in a soil sample can be misleading. Only half of the eggs in one cyst will hatch after the first year, about half of the remaining eggs will hatch in the second year and half again in the third.

For example, if a female nematode initially produces 200 eggs, only 100 of these or half the eggs will hatch after the first year; 50 after the second; and 25 after the third. A population count based on a large number of third-year cysts would thus exaggerate the severity of the potential nematode problem.

To avoid this exaggeration, Griffin counts the number of viable larvae and eggs contained in the cysts.

Griffin has found a high correlation between the number of larvae and eggs per gram of soil sample and the reduction of sugarbeet growth. Correspondingly, his studies show a low correlation between the number of cysts per gram of soil and economic damage.

Dr. Gerald D. Griffin is located at the Crops Research Laboratory, Room 215, Utah State University, Logan, UT 84322. —(By Lynn Yarris, SEA, Oakland, Calif.)

Rapid Potato Leafroll Virus Test. By estimating the percentage of plants infected with potato leafroll virus, a new, rapid test should help the potato industry decide which lots of tubers to store and which to process immediately.

Leafroll virus is one of the most common potato diseases. The virus causes infected tubers in storage to develop net necrosis, a symptom of the disease that results in extensive tuber deterioration.

Developed by SEA plant pathologist Peter E. Thomas, Prosser, Wash., the test involves extracting chlorophyll from potato leaves, then staining the leaves with iodine. An appearance of black on all or part of a leaf is a positive reading for leafroll virus.

Thomas' test has been 100 percent accurate in detecting leafroll virus in Russet Burbank potatoes and slightly less accurate for Kennebeck and Norgold varieties. In a field test for chronic leafroll, the test proved to be 90 percent accurate.

Until now, determining how widespread a leafroll infection is in any given potato field has been generally impossible. With no test available, growers relied on visual inspection.

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